Separation distances around livestock buildings derived with two models

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Outline of the presentation

- How to deal with short-term odour peaks in dispersion models
- The peak-to-mean approach in the Gaussian Austrian Odour Dispersion Model AODM: „general“ attenuation function; application to the Lagrange model LASAT (post-processing mode)
- Site-specific approach by use of data from ultrasonic anemometers (Obukhov stability parameter)
- Site-specific attenuation functions for two models
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- Effect on separation distances
- Summary and conclusions

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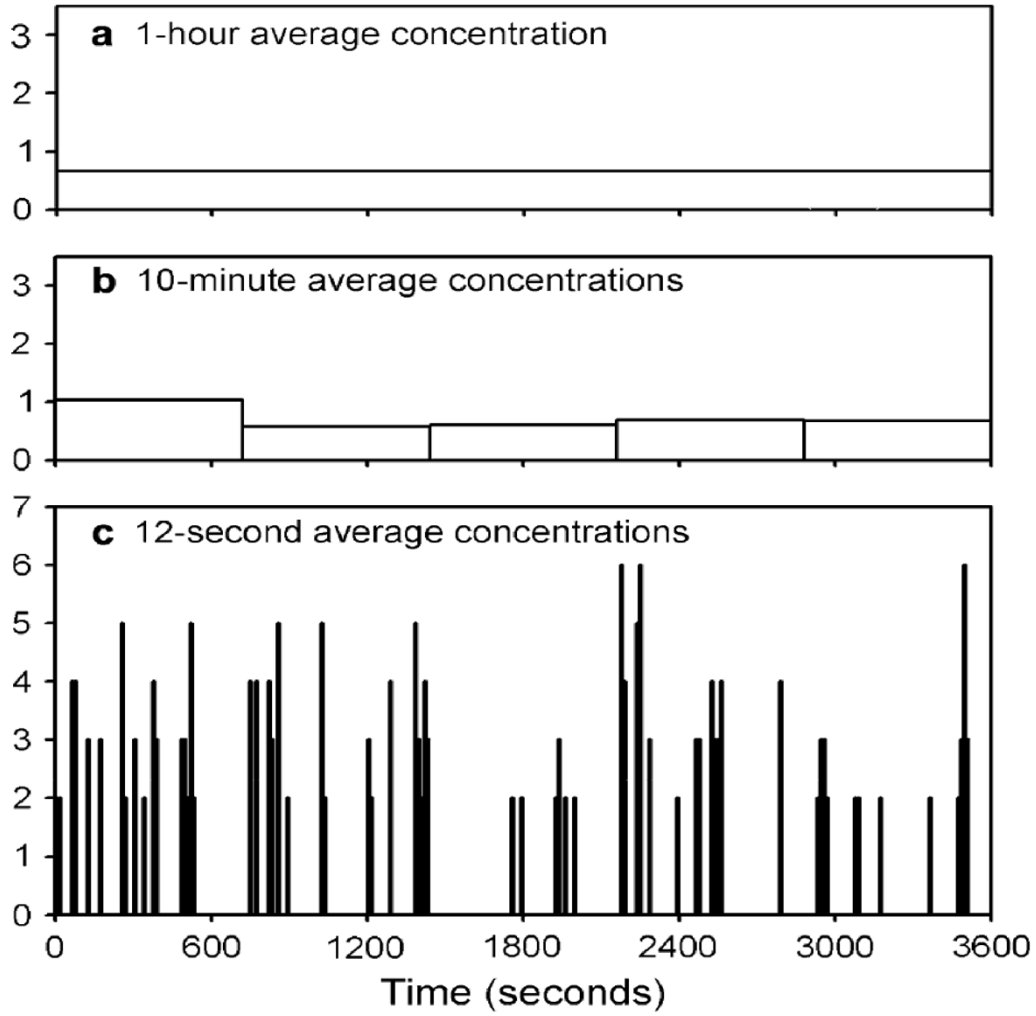
1 hour-mean vs. instantaneous odour concentrations

Martin Piringer



Time course of the odour concentration (ou_E/m^3) for three time intervals.

(a) one-hour mean value (e.g. output of a dispersion model)

(b) 12-min and

(c) 12-s mean odour concentrations observed at a single receptor point during a field study.

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Peak-to-mean module in AODM

$$\Psi_0 = \frac{C_p}{C_m} \qquad \frac{C_p}{C_m} = \left(\frac{t_m}{t_p}\right)^a$$

Smith (1973)

C_m: mean concentration for an integration time of t_m (30 min.)

C_p: peak concentration for an integration time of t_p (5 sec.)

a: exponent depending on the stability of the atmosphere

Ψ_0: peak-to-mean factor close to the source

Stability class		Beychok (1994)	
		Exp. a	ψ_0
2	very unstable	0,68	54,74
3	unstable	0,55	25,47
4	neutral	0,43	12,57
5	slight stable	0,30	5,85
6	stable	0,18	2,88
7	very stable	0,18	2,88

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Peak-to-Mean depending on the distance I

$$\Psi = 1 + (\Psi_o - 1)\exp\left(-0.7317\frac{T}{t_L}\right)$$

$$T = \frac{x}{u}$$

Mylne and Mason (1991)

$t_L = \sigma^2/\varepsilon$

t_L Lagrangian time scale
σ^2 Variance of the wind velocity
ε Dissipation of turbulent energy

$$\sigma^2 = \tfrac{1}{3}(\sigma_u{}^2 + \sigma_v{}^2 + \sigma_w{}^2)$$

$$\varepsilon = \frac{1}{k\,z}\left(\frac{\sigma_w}{1.3}\right)^3$$

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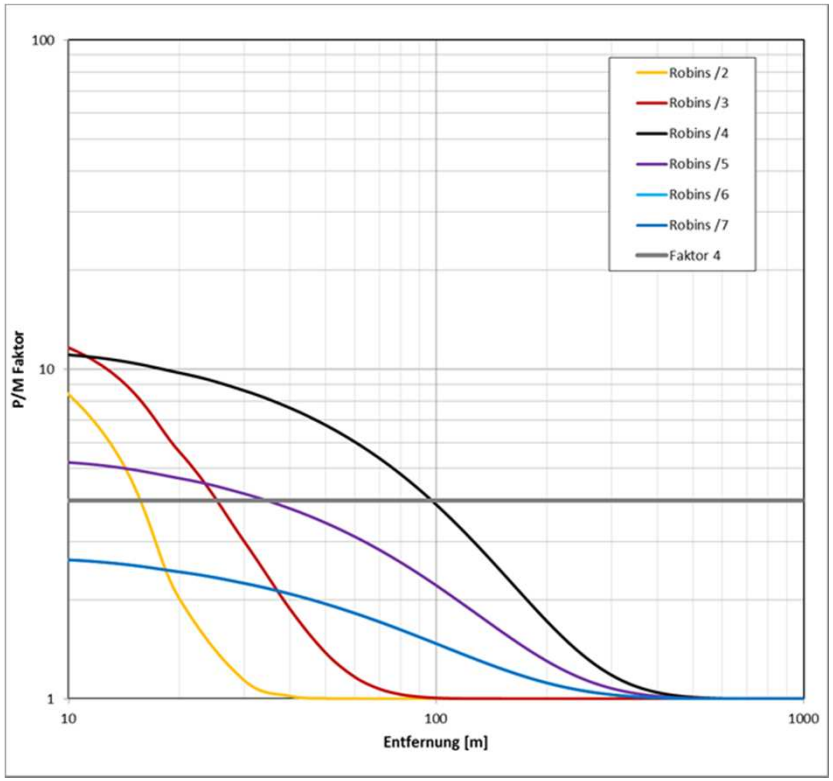
Site-independent attenuation curves

Stability class		σ_u/u	σ_v/u	σ_w/u
2	very unstable	0,2	0,2	0,3
3	unstable	0,2	0,2	0,2
4	neutral	0,2	0,2	0,1
5	slight stable	0,2	0,2	0,1
6	stable	0,2	0,2	0,1
7	very stable	0,2	0,2	0,1

From a reference (Robins, 1979)

Variation of σ_w/u with atmospheric stability according to our experience with Sodar data (vertical wind profiles)



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Stability from ultrasonic anemometers

- Determined by the Obukhov stability parameter OSP (m^{-1}) and the local roughness length

Stability class		Roughness length z_0 [m]					
Reuter/ON		0.01	0.02	0.05	0.1	0.2	0.5
7	very stable	0,080	0,070	0,055	0,050	0,045	0,040
	Class limit	0,059	0,050	0,039	0,033	0,028	0,025
6	stable	0,040	0,030	0,025	0,020	0,017	0,015
	Class limit	0,020	0,015	0,012	0,010	0,008	0,006
5	slightly stable	0,012	0,010	0,008	0,007	0,006	0,005
	Class limit	0,006	0,005	0,005	0,004	0,003	0,002
4	neutral	0,000	0,000	0,000	0,000	0,000	0,000
	Class limit	-0,025	-0,020	-0,016	-0,012	-0,010	-0,005
3	unstable	-0,045	-0,040	-0,030	-0,025	-0,020	-0,010
	Class limit	-0,066	-0,060	-0,050	-0,040	-0,030	-0,015
2	very unstable	-0,085	-0,080	-0,070	-0,060	-0,050	-0,040

Stability class		Roughness length z_0 (m)							
Klug-Manier		0,01	0,02	0,05	0,10	0,20	0,50	1	1,5
I	very stable	0,175	0,124	0,078	0,055	0,039	0,025	0,017	0,014
	Class limit	0,122	0,087	0,055	0,039	0,027	0,017	0,012	0,010
II	stable	0,049	0,035	0,022	0,015	0,011	0,007	0,005	0,004
	Class limit	0,024	0,017	0,011	0,008	0,005	0,003	0,002	0,002
III/1	neutral/night	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Class limit	-0,017	-0,012	-0,008	-0,006	-0,004	-0,002	-0,002	-0,001
III/2	neutral/day	-0,041	-0,029	-0,018	-0,013	-0,009	-0,006	-0,004	-0,003
	Class limit	-0,061	-0,043	-0,027	-0,019	-0,014	-0,009	-0,006	-0,005
IV	unstable	-0,082	-0,058	-0,037	-0,026	-0,018	-0,012	-0,008	-0,007
	Class limit	-0,122	-0,087	-0,055	-0,039	-0,027	-0,017	-0,012	-0,010
V	very unstable	-0,175	-0,124	-0,078	-0,055	-0,039	-0,025	-0,017	-0,014

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Attenuation curves for Kittsee - AODM

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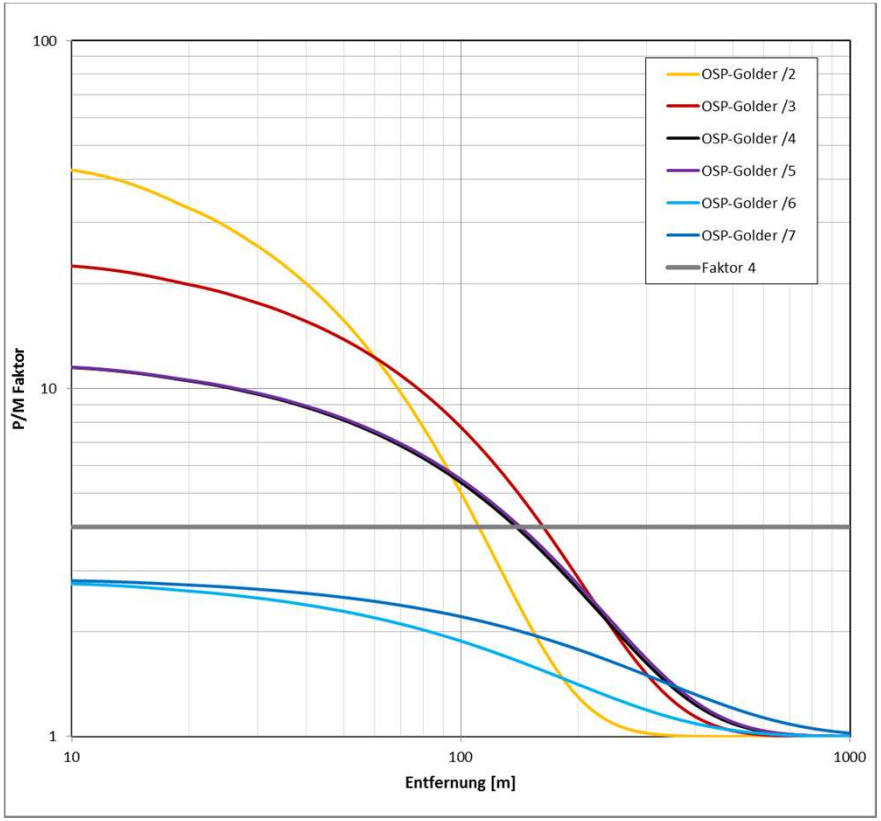
OSP-Golder z0=0.02	σ_u/u	σ_v/u	σ_w/u	Exp. *u*
< -0,060	0,39	0,38	0,19	0,68
-0,060 bis -0,020	0,26	0,26	0,12	0,55
-0,020 bis 0,005	0,19	0,17	0,08	0,43
0,005 bis 0,015	0,19	0,15	0,08	0,43
0,015 bis 0,050	0,20	0,18	0,08	0,18
> 0,050	0,20	0,19	0,07	0,18

From ultrasonic anemometer measurements

Variation of all sigma values with atmospheric stability; larger peak-to-mean values for unstable conditions



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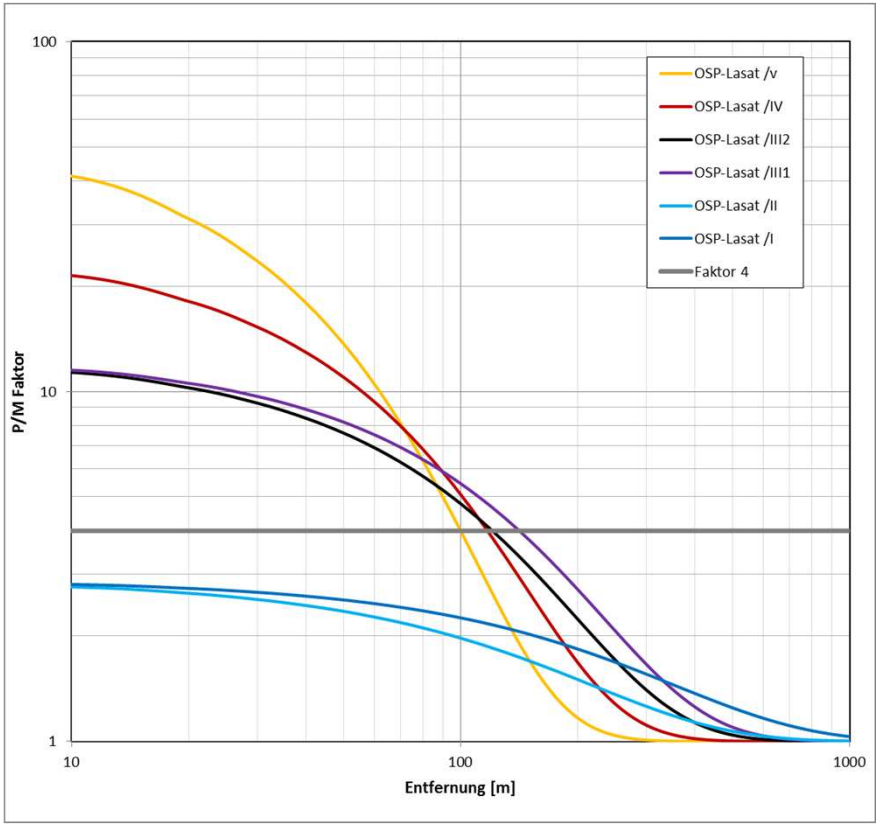
Attenuation curves for Kittsee - LASAT

OSP-Lasat z0=0.02	σ_u/u	σ_v/u	σ_w/u	Exp. *u*
< -0,087	0,41	0,39	0,20	0,68
-0,087 bis -0,043	0,34	0,33	0,15	0,55
-0,043 bis -0,012	0,23	0,23	0,10	0,43
-0,012 bis 0,017	0,19	0,16	0,08	0,43
0,017 bis 0,087	0,20	0,18	0,07	0,18
> 0,087	0,20	0,19	0,06	0,18

From ultrasonic anemometer measurements

Variation of all sigma values with atmospheric stability; larger peak-to-mean values for unstable conditions; small differences to AODM curves



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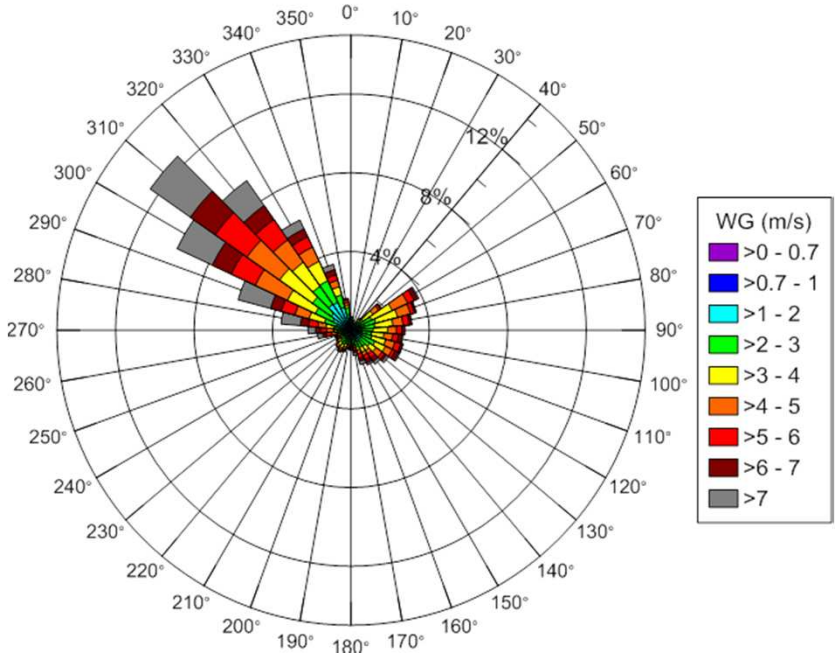
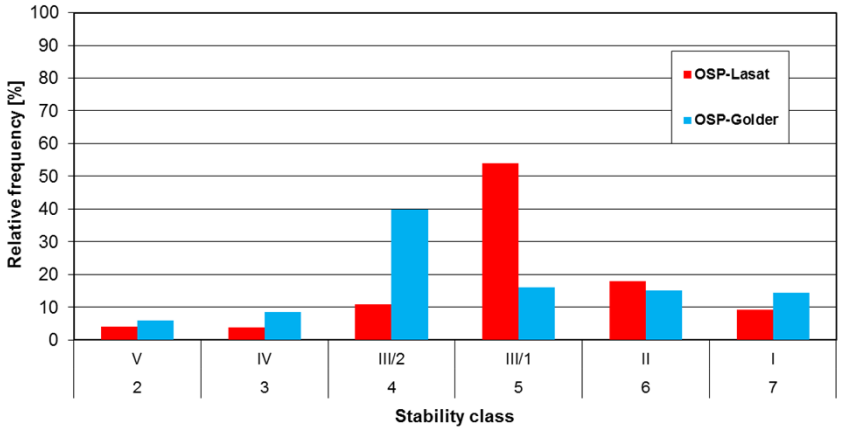
Wind and stability at Kittsee



Wind rose for Kittsee
Colours denote wind speed



Blue: Austrian scheme with classes 2 (unstable) to 7 (stable)
Red: German scheme with classes V (unstable) to I (stable)

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Emission data

Stack height	[m]	8,0
Stack diameter	[m]	2,7
Exit velocity	[ms^{-1}]	3,0
Volume flow	[m^3h^{-1}]	60.000
Temperature	[℃]	20
Source strength	[$OU_E s^{-1}$]	5.200

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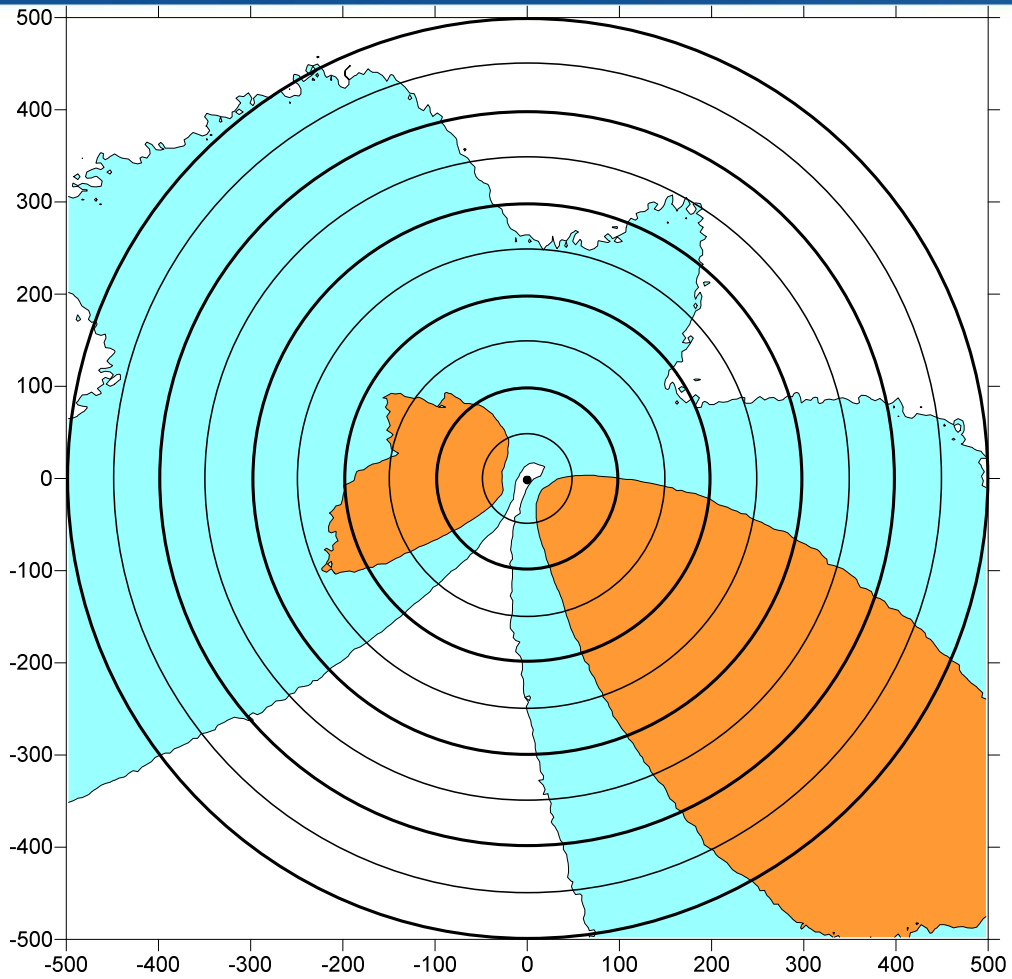
Results: Separation distances (I)



Separation distances are calculated for selected odour impact criteria, a combination of odour threshold and selected exceedance probability according to land use (here 3 (blue) and 8 % (orange))

LASAT Factor 4: very large separation distances, esp. leewards of main wind direction with highest average wind speeds

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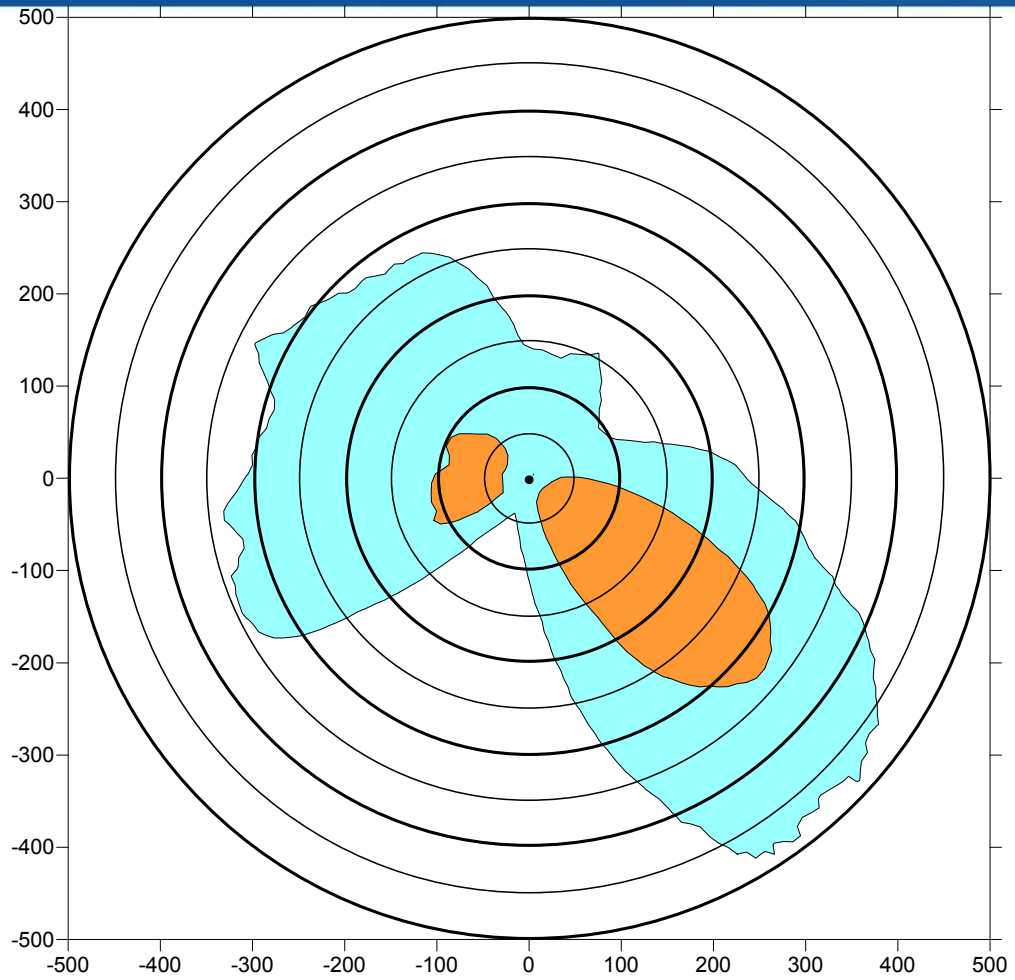
Results: Separation distances (II)



Separation distances are calculated for selected odour impact criteria, a combination of odour threshold and selected exceedance probability according to land use (here 3 (blue) and 8 % (orange))

LASAT USA: separation distances now reduced to a plausible range

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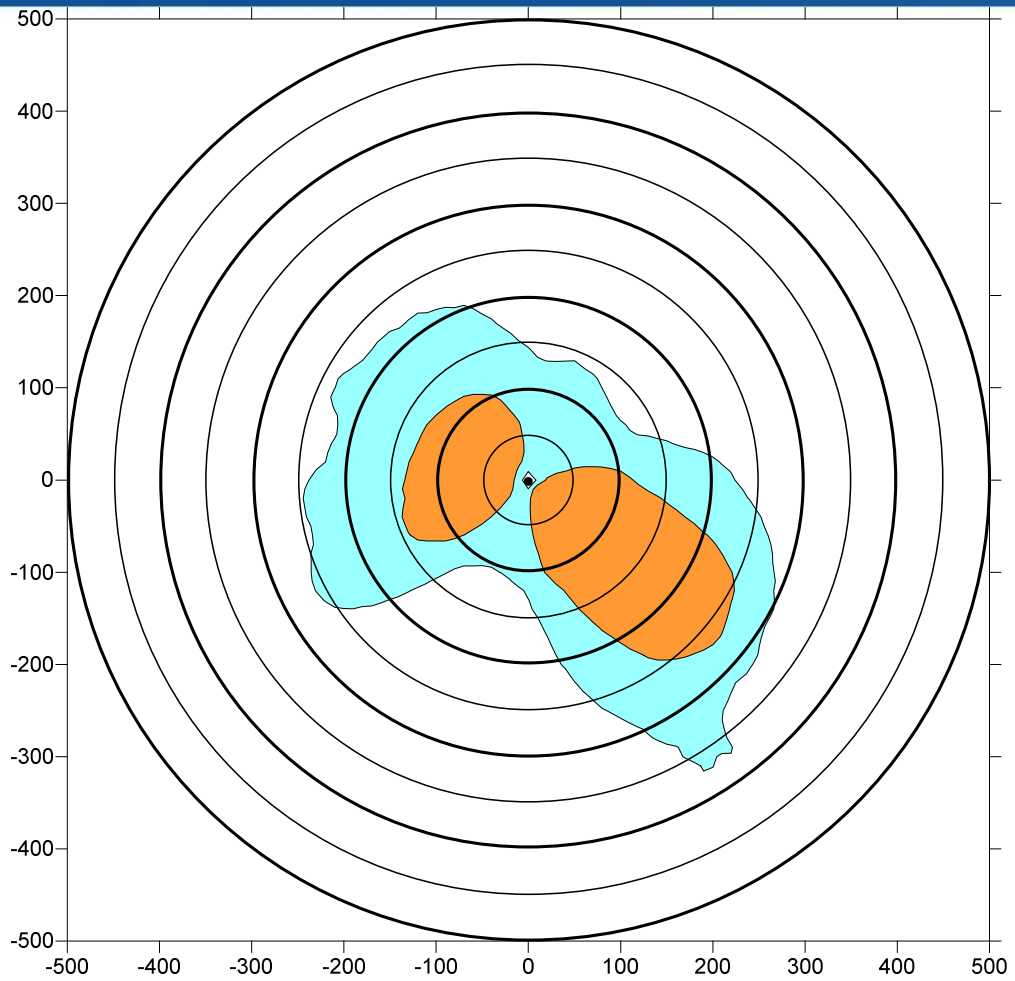
Results: Separation distances (III)



Separation distances are calculated for selected odour impact criteria, a combination of odour threshold and selected exceedance probability according to land use (here 3 (blue) and 8 % (orange))

AODM USA: separation distances shorter for 3 %, larger for 8 % exceedance probability

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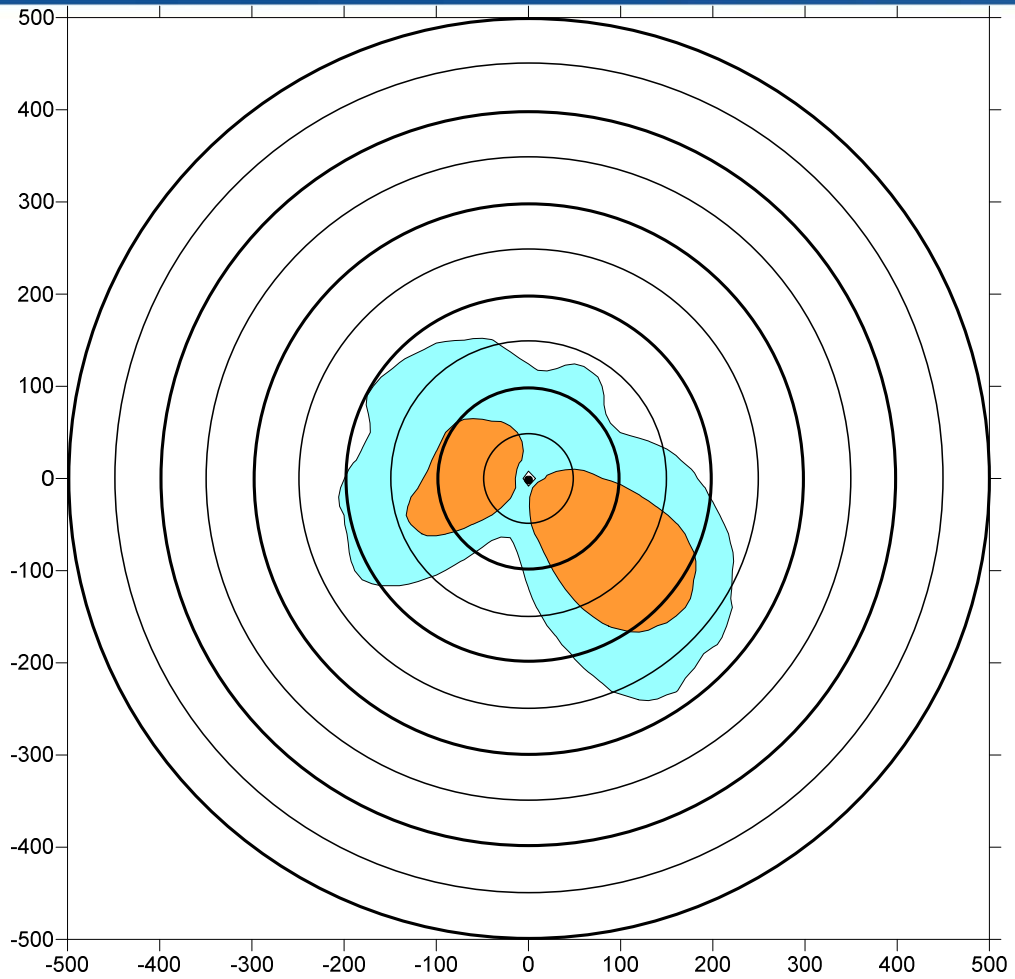
Results: Separation distances (IV)



Separation distances are calculated for selected odour impact criteria, a combination of odour threshold and selected exceedance probability according to land use (here 3 (blue) and 8 % (orange))

AODM Standard: separation distances further shortened, use of sonic data recommended for site-specific assessment

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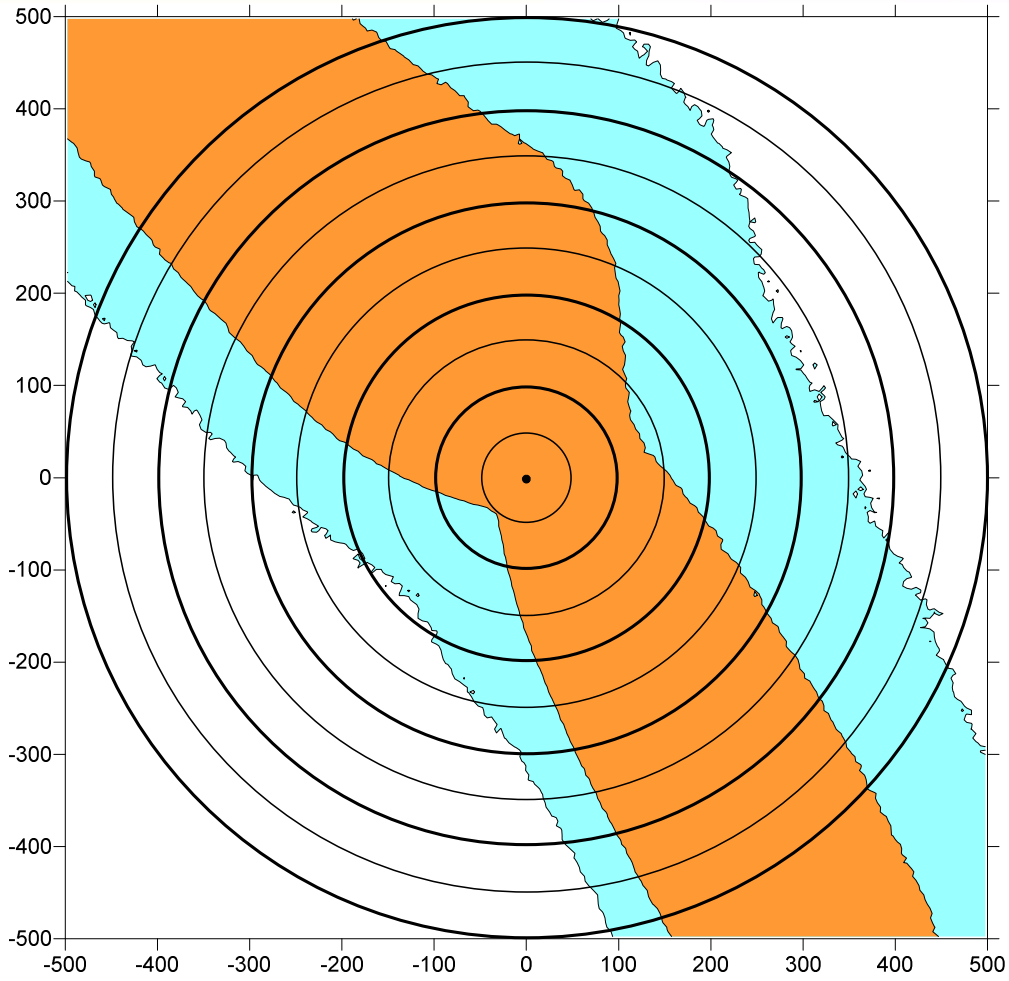
Example: Application of factor 4 to an Alpine valley



Separation distances are calculated for selected odour impact criteria, a combination of odour threshold and selected exceedance probability according to land use (here 3 (blue) and 8 % (orange))

LASAT Factor 4: caution when applying this method to an Alpine valley with channelled flow and weak winds; exceedance areas very much elongated

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Summary and conclusions

- Peak-to-mean module of AODM can in principle be applied to other models
- Use with LASAT widens applicability to built-up areas and moderately complex terrain
- Separation distances of the two models comparable (except factor 4); LASAT shows a tendency for larger separation distances than AODM
- Site-specific attenuation functions reflect better local conditions
- Application of factor 4: caution esp. in valleys and basins

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